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LOSS OF LIFE IN THE UNITED STATES BY LIGHTNING.

Prepared under the direction of WILLIS L. MOORE, Chief U. S. Weather Bureau,

BY

ALFRED J. HENRY,
PROFESSOR OF METEOROLOGY.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., December 3, 1901.

Hon. JAMES WILSON,
Secretary of Agriculture.

SIR: I have the honor to transmit herewith a paper by Alfred J. Henry, professor of meteorology, entitled *Loss of Life in the United States by Lightning*, and to recommend its publication as a bulletin of the Weather Bureau.

The aim of the paper is to furnish accurate information as to the destruction of human life annually by lightning; to point out the regions where the greatest loss of life occurs; and, so far as practicable, to call attention to the few simple precautions against danger that may be exercised by the individual.

Very respectfully,

WILLIS L. MOORE,

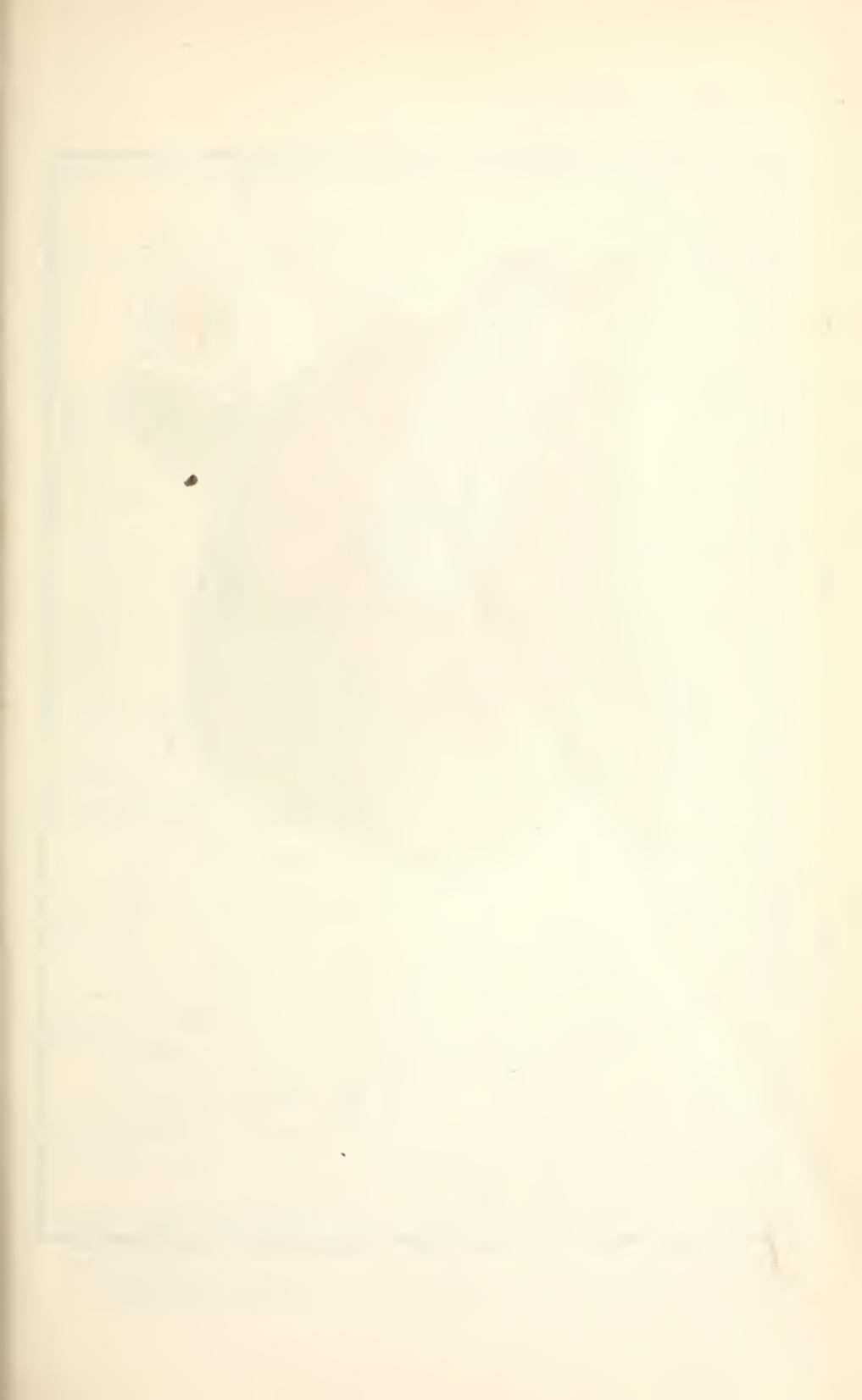
Chief United States Weather Bureau.

Approved.

JAMES WILSON, *Secretary.*

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LOSS OF LIFE IN THE UNITED STATES BY LIGHTNING.

About a dozen years ago the opinion was expressed that more lives were lost by lightning than by violent winds and tornadoes. In order to determine as accurately as might be the number of fatalities from each of the two above-mentioned causes, a statistical inquiry was set on foot in 1890 and the inquiry has been maintained, so far as lightning is concerned, up to and including the calender year 1900. The number of fatal cases of lightning stroke was obtained at first by scanning four of the largest and most important newspapers in the country. At a later period the active cooperation of the officials in charge of Weather Bureau stations in the large cities was solicited; and, finally, in 1899, in order that there might be no reasonable doubt as to the accuracy of the statistics being thus collected, the aid of one of the largest clipping bureaus in New York City was invoked. The number of clippings received from the clipping bureau alone, during the two years 1899 and 1900, was nearly 30,000. In this large number taken from newspapers, representing all parts of the country, there were naturally many duplicates, the number depending somewhat upon the value of the clipping as a news item. In some cases as many as 50 clippings were received, all of which referred to the same event although published on different dates and in different newspapers. The very great labor involved in identifying and classifying the thousands of clippings received annually, and the conviction that no useful purpose would be served by the further collection of such bald facts as are usually contained in a newspaper narrative of lightning phenomena, led to the abandonment of the work at the close of 1900.

The inquiry was begun in 1890 and has, therefore, extended over eleven years; it is now known that the results for the earlier years are incomplete and the reason is not far to seek. The greatest number of fatalities occur in rural districts some distance from telegraph and telephone lines, and the great news centers. The death of the victim is generally chronicled in the county paper, but rarely in press dispatches and the larger dailies. Some of the large daily papers of the Middle West contain much information concerning deaths by storm and lightning throughout the Mississippi and Missouri valleys and the

Southwest, yet their correspondents can cover at best but a relatively small proportion of that great domain. In the older and more densely populated Middle Atlantic districts the information at hand is much more complete; yet, after all, it is only when every county paper in the land has been carefully scanned that we may feel assured that our results are, at least, approximately correct.

It is the particular sphere of the county newspaper to chronicle events happening within the geographic boundaries of its constituency and, moreover, unlike the daily newspaper, it is not deterred from publishing an item merely because the event happened a fortnight ago. The earlier statistics of loss of life and property by lightning are defective because the county newspapers were not examined. Our present knowledge of the death rate by lightning would be greatly increased if all local and State boards of health would segregate deaths due to lightning from deaths due to other causes, as is now done in some States, notably Minnesota, Michigan, Massachusetts, and a few others.

The number of persons killed by lightning during 1900 is given by months and States in Table I, the number injured in Table II. Seven hundred and thirteen persons were killed or received fatal injuries during the year. Of this number 291 persons were killed in the open, 158 in houses, 57 under trees, and 56 in barns. The circumstances attending the death of the remaining 151 are not known. Nine hundred and seventy-three persons were more or less injured by lightning stroke during the year. Of this number 327 persons received their injuries while in houses, 243 in the open, 57 in barns, and 29 under trees. The circumstances attending the injury of the remaining 317 cases are not known.

The foregoing statements briefly sum up the net results of the ravages by lightning in a single year. The summary itself tells little, nor can it, of the infinite variety of external circumstances attending the destruction of so many people. Some were stricken in their homes, some on the highways, some in the field or barn, and some while seeking temporary shelter under trees. It has been pointed out again and again that it is not safe to take refuge from a thunderstorm under a tree. Doubtless most of those who perished while under trees would be alive to-day had they remained in the open. It is also injudicious to huddle under thrashing machines, sheds, or in the so-called "grand stands" pertaining to race tracks or county fairs, especially under or near the flagstaff. Men, like animals, are killed not singly, but in bunches when they huddle together.

The record of death by months for the eleven years, 1890-1900, appears in Table III. The most striking feature of that table is the great apparent increase in the number of deaths in 1899 and 1900. As before stated, however, the means adopted to ascertain the casual-

ties in those years were very much more complete and extensive than had been previously used.

The writer has had personal cognizance of the methods in vogue from the beginning of the inquiry in 1890 until it was closed in 1900. It is his belief that the statistics (1899 and 1900) express very nearly the actual loss by lightning in the United States annually. The number may and probably does vary as much as 10 per cent above or below the average of those years, but it may be accepted as a fact, developed by this inquiry, that from 700 to 800 lives are lost each year by lightning stroke.

In a previous paper on this subject (Bulletin No. 26, Lightning and the Electricity of the Air, A. G. McAdie and Alfred J. Henry) the writer had occasion to discuss the relative frequency of fatalities by lightning in the several States and Territories. At that time, since the statistics covered but three years, it was thought inexpedient to attempt to draw conclusions from them. The addition of the very complete data for the years 1899 and 1900 to the previous record makes it possible to form some idea of the death rate due to lightning in the various States and Territories. It is obvious that the number of fatalities must depend partly upon the frequency of lightning strokes per unit area, partly upon the density of population, and partly upon the character of the thunderstorms which traverse the region. In the United States, thunderstorms occur with considerable frequency over all of the territory east of the one hundredth meridian, save a narrow strip along the northern border. West of the above-named meridian, except in the Rocky Mountain region, the frequency steadily diminishes, reaching practically zero along the immediate Pacific coast. There are three regions of maximum thunderstorm frequency, viz., one in the southeast, with its crest over Florida, one in the Middle Mississippi Valley, and one in the Middle Missouri Valley. (See Plate I.) The average number of days annually with thunderstorms in the first-named region is 45; in the second, 35, and in the last, 30.

Table IV has been constructed to show the average mortality according to geographic districts, subject approximately to the same or nearly the same atmospheric conditions. The nature of the data in the several columns is shown with sufficient clearness by the headings.

The greatest number of fatal cases, according to the figures in column 3, occurred in the Middle Atlantic States, and the next greatest in the Ohio Valley and Tennessee, with the Middle and Upper Mississippi Valley a close third. The greatest number of deaths in any single State during the five years, 1896-1900, occurred in Pennsylvania—186—followed by Ohio with 135, and Indiana, Illinois, and New York with 124 each.

The greatest fatality from a single stroke occurred at Chicago, Ill., where 11 persons, huddled together in a zinc-lined shanty under a North Shore pier, met instant death by a single bolt.

The chance of being struck by lightning evidently depends, as before stated, upon the frequency of lightning stroke per unit area; the total number of cases upon both the frequency of lightning stroke and the density of population. It is evident that the number of lightning strokes which fall in any State in a year, other things being equal, must depend upon the area of the State. It is also evident that the number of casualties will be greater the greater the number of persons exposed to effects of thunderstorm action. Accordingly the casualties have been classed under three different heads: First, in column 4, as the rate per million of rural population; second, in column 5, as the rate per million of total population; and finally, in column 6, as the average number per unit area of 10,000 square miles.

Some interesting comparisons may be made from these figures; thus, in the Gulf States, the average number of deaths due to lightning per unit area is but 1, although the average thunderstorm frequency is quite high. In New England, with probably only half as many thunderstorms, the death rate per unit area is 2. There being no large cities in the South, the rate per million of rural population and total population is practically the same, viz, 6 and 5 in the Gulf States, and 9 and 8, respectively, in the South Atlantic States.

The belief that the chance of injury by lightning in the cities is less than in the country is rather general. What foundation, in fact, such a belief has is hard to determine. It is not sufficient to show simply that a given area in any city is free from lightning stroke. It must be shown that an equal area outside of the city is subject to lightning stroke. When the combined area of the large cities is compared with the immense territory embraced in the rural districts it is not surprising that so few lightning strokes fall in cities. The modern city building, with its metallic roof and steel frame, is a fairly good conductor of electricity, and is in much less danger of receiving a damaging stroke of lightning than an isolated dwelling in the open country. The multiplication of telegraph, telephone, and electric light wires in cities also adds to the effectiveness of silent discharges in relieving the electric tension during a thunderstorm; but should a cloud with a tremendous store of energy quickly approach, all of the wires in ten cities would not prevent it from discharging right and left until its store of energy had been dissipated.

In New England the death rate by lightning per million of rural inhabitants is nearly double that per million of total population, and the same holds true of the densely-populated districts of the Middle Atlantic States. The large urban population of New York reduces the rate per million of total population in that State to but three, whereas in the neighboring State of Pennsylvania it is six. Both States are subject to practically the same atmospheric conditions and have the same percentage of deaths by lightning, if rural population only be considered.

We should therefore infer that statistics of death by lightning based on total population are not comparable except for areas having about the same density of population.

The greatest mortality by lightning, considering both unit area and density of population, is in the Ohio Valley and the Middle Atlantic States; if, however, density of population only be considered, it is in the Upper Missouri Valley and the middle Rocky Mountain region. The record of deaths by lightning in the middle Rocky Mountain region is rather surprising, in view of the vast extent of territory involved, the diversified character of its topography, and the sparsity of its population. The very large mortality in the mountainous States of Colorado, Montana, and Wyoming, and in the two Dakotas should emphasize the necessity on the part of persons living in those States of taking all known precautions to avoid the danger of lightning stroke.

Plate II shows the geographic distribution of fatal cases of lightning stroke in the United States. The chart is based on the figures of column 6, Table IV. Broadly stated, these figures represent the average number of fatal cases annually per unit area of 10,000 square miles.

It has often been suggested that an extended system of experiments should be made by the Government with a view of making life and property more secure during thunderstorms. The answer to this lies in the obvious difficulty of experimenting with a force that is manifested on such a tremendous scale as that of lightning. It is true that a discharge can be produced in the laboratory which in some respects resembles the lightning flash. The modern alternating machine and the device of a transformer enable one to study the character of lightning much more successfully than is possible by means of the ordinary frictional electrical machine; but while discharges of high electro-motive force and great quantity can be obtained, yet the lightning flash of a mile or more in length so far transcends, in the tremendous potential to which it is charged, anything that can be produced in the laboratory that it seems hopeless to expect any material aid from experiments in the latter.

We may, perhaps, better understand the phenomenon of a lightning flash by noting the similarity between it and the discharge of a Leyden jar. The Leyden jar, it may be remembered, consists of a glass jar, coated both inside and out with tin foil for about four-fifths of its height. The mouth is closed by a cork, through which passes a metallic rod, terminating above in a knob and connected below with the inner coating, usually by a chain depending from it. The two coatings of the jar obviously serve as collecting and condensing surfaces and form, in connection with the glass jar, what is known in electrical terminology as a condenser. The capacity of a conductor may be enormously increased by bringing near it another conductor connected with the earth. This process is called "condensation of electricity." If the

inner coating of a Leyden jar be connected with an electrical machine and the outer with the earth, the former will acquire a positive and the latter a negative charge. If now a metallic rod be brought near the two surfaces of the jar a spark is obtained whose power depends on the potential of the inner coating and on its electrical capacity.

If the jar has not been charged beyond its capacity it will retain its charge, under favorable conditions, for many days. If, on the other hand, the inner coating has been too highly charged partial discharges, invisible except as a phosphorescent glow in the dark, will occur from the inner to the outer coating until equilibrium is restored. Again, if a jar be subjected to a sudden rush of electricity it will overflow, that is to say, sparks will pass along the glass from the inner coating up over the lip of the jar and down the other side to the outer coating. Thus, we have seen that the overcharge of a jar may be dissipated by weak, partial discharges and also by a true spark discharge of some violence. The analogy between these two forms of discharge and what occurs in nature may be better perceived when we consider the layer of cloud as one coating of the jar and the surface of the earth as the other, while the air between takes the place of the glass of the jar. The glass of the jar, or in fact any insulating substance between two charged surfaces, is called the dielectric, and it is in this dielectric of nonconducting air between the clouds and the earth that we live.

In ordinary fine weather the upper regions of the atmosphere are at a different potential from the earth, but the difference in potential or pressure, if we may use the last term, is not great enough to produce a discharge. The sparking distance is too great, and, as in the case of the Leyden jar, no discharge will take place so long as the electrical tension remains unchanged.

It is well known that certain conditions of temperature, atmospheric pressure, and moisture favor the development of thunderstorms. Under such conditions the potential difference between the cloud on the one hand and the surface of the earth on the other is increased, not gradually and for some time in advance of the thunderstorm, but rather suddenly, and more often locally than simultaneously over a large extent of territory. The cloud serves as a condenser of enormous extent, as compared with those used in laboratory experiments, but, nevertheless, the amount of charged surface presented to the earth may not, in the case of summer thunderstorms, exceed a few square miles. We have then, following out the analogy between a Leyden jar and a flash of lightning, a few square miles of cloud as one coating of the jar, an equal area of land as the other with the air between subject to stress or tension. As in the case of the overcharged Leyden jar, the tension may be relieved by invisible or silent discharges from the top of every rock, building, tree, wire or other metallic object within the strained field, as well as from the undersurface of the cloud.

Discharges of this character may and do take place through the human body, especially on high mountain summits, where the discharge at times is so marked as to cause apprehension for one's safety.

Up to a certain point the air is able to resist the stress in it due to the electrification of the cloud mass. Whenever the stress passes a certain limit, which may be called the breaking point, the air gives way; literally it is cracked from cloud to earth like a piece of glass as the bolt descends. While human foresight is able to say approximately when a flash will occur, it can not say where the air will give way first. The zone of danger is in general coequal with the area of the storm cloud, although it sometimes spreads out some distance in front of the storm cloud. Almost any upright object in this area is a better conductor than the air in which it stands. The wonder is therefore not that so many persons and objects are struck, but that so many escape.

The ability of an electric current to break down a core of nonconducting air depends upon its electro-motive force. A current of 10,000 volts will jump across a space of about half an inch of common air, and hence it has been concluded that a flash of lightning that extends from cloud to earth must have an electro-motive force of many millions of volts. Since many thunderstorm clouds are at least a mile above the earth, we must continue to marvel at the source of the tremendous energy involved in a single thunderstorm.

The underlying causes of the electrical manifestations in a thunderstorm have not yet been clearly defined. It is known, of course, that the normal electric field of fair weather becomes disturbed concomitantly with certain other changes in the meteorological conditions, but no such relation as that of cause and effect has as yet been discovered. It is also well known that certain conditions of heat, wind, and moisture are present in the formation of thunderstorms, and it is, therefore, suspected that motion of some sort, whether mechanical, as of the wind, causing friction between the air particles; or molecular, as when water vapor is condensed into a liquid, is in some way the antecedent of the disturbed condition of the normal electric field. That there is some connection between the condensation of aqueous vapor and the electrical state of the atmosphere seems quite probable, but just what the relation is does not yet appear. The writer has observed the transformation of a plain cumulus cloud into a thunderstorm on more than one occasion. Rain almost invariably began before there was any display of lightning whatever. The first manifestations of the latter were usually in the form of light thread-like discharges within the cloud, without audible thunder. As the rain increased and the wind freshened the electrical discharges became more marked. These observations, though quite fragmentary, evidently indicate that the electrical tension of the air is increased by precipitation.

The very interesting and suggestive experiments of Townsend, Wilson, and others in the Cavendish Laboratory, Cambridge (England), have shown among other things that an electrified gas possesses the remarkable property of producing a fog when admitted into a vessel containing aqueous vapor and this without any lowering of temperature, such as would be produced by the sudden expansion of the gas in the vessel in which the fog is produced.

The effect observed by the late Robert von Helmholtz, *viz.*, that a light semitransparent cloud of steam issuing from the orifice of a vessel was darkened and rendered much more opaque by the discharge of electricity into it, points also to a connection of some sort between the condensation of water vapor and the electrical state of the atmosphere. On the other hand, the atmosphere may become highly electrified and all of the outward signs may point to rain, yet no condensation takes place, whether from lack of moisture in the air or some other cause is not known. The following description of an electrical and dust storm, by the late Dr. J. C. Neal, director of the Oklahoma Agricultural and Mechanical College at Stillwater, was published in the *Monthly Weather Review* of January, 1895:

During the morning of January 20 [1895] the sky was filled with cirrus clouds, very feathery and white. In the afternoon it became hazy, then dark, and looked like rain. Wind in puffs from the southwest. At nightfall the sky cleared, but somewhat hazy. At 8 p. m., seventy-fifth meridian time, the wind changed to the west, and a gale began; by 9 p. m. it was frightful. The dust passed along in columns fully 1,000 feet high; the wind rose to a speed of 35, then 45 miles per hour, with gusts reaching 55 miles; the temperature fell rapidly, and we saw for the first time (about 9 p. m.) flashes of light that apparently started from no particular place, but pervaded the dust everywhere. As long as the wind blew, till about 2 a. m., January 21, this free lightning was everywhere, but there was no noise whatever. It was a silent electrical storm. This morning the sky is clear and, except that the dirt is piled up over books, windows, and in all the house, no one would know what a fierce raging of wind and sky we had.

Somewhat similar storms have been observed in western Kansas, eastern Colorado, and probably elsewhere in the eastern foothills of the Rocky Mountains. Mr. T. B. Jennings, section director of the Kansas climate and crop service, reports that the western counties of that State are occasionally swept by windstorms, called by the plainsmen electrical storms, although no lightning is seen and the weather is generally clear. The winds in these storms are generally of great force and sweep over large areas. Persons exposed to them become so strongly charged with electricity that a spark will readily pass from their hands to a metal object.

Electrical displays, similar to that observed by Dr. Neal in the dry climate of the West, without rain, have been observed in the West Indies and the humid regions of the eastern part of the United States with rain; so far therefore as crude observations of this sort are

concerned, the dependence of rain upon the electrical state of the atmosphere is not established.

The occurrence of thunderstorms in the United States is not limited to the warm season, although the great majority of such storms happens in the months of June, July, and August. Winter thunderstorms are not infrequent in the Gulf States, and occasionally extend northeastward along the Atlantic coast to Massachusetts. At the close of winter the region of most frequent thunderstorms is in the Lower Mississippi Valley. In the spring months the area of greatest frequency extends rapidly northward, overspreading the Upper and middle Mississippi and the Missouri valleys by the end of April. The rainy season of the Great Plains region and the northeastern Rocky Mountain Slope sets in about the end of April, and from that time to the middle or end of July thunderstorms are of frequent occurrence. The season of greatest thunderstorm frequency east of the Alleghenies, especially in New England, does not set in until about the 1st of July, but lasts well into September.

As stated on a previous page, there is not that accordance between the number of lives lost by lightning stroke in the different parts of the country and the number of thunderstorms which might be expected. The low percentage of deaths in the Gulf States and Florida, where the average number of thunderstorms is higher than elsewhere, may possibly be ascribed to two causes: First, the sparseness of the population; and, second, to the less violent character of the thunderstorms which prevail in that region. The writer is aware of the difficulty in proving satisfactorily that the thunderstorms of one region are more violent than those of another. There is lacking, first of all, a convenient standard whereby one storm may be compared with another. In the second place, the thunderstorms of any region differ greatly among themselves, considering only the electrical manifestations. It is customary among observers to record as a full-fledged thunderstorm any disturbance in which a single distinct peal of thunder is heard, and thus the record is composed of a large number of thunderstorms of varying intensity. A storm may consist of many brilliant though harmless discharges from one portion of the cloud to another or from one cloud to another cloud, but no discharges from cloud to earth. Again, the discharges may be few in number, but violent and destructive of life and property.

Following the classification of Mohn, thunderstorms may be divided into two kinds, viz, heat and cyclonic, although it is quite probable that the great majority are a combination of these two forms. A third class, viz, winter thunderstorms, is sometimes added. In the United States winter thunderstorms may be classed as cyclonic, since they are rarely observed, except in connection with a well-marked cyclonic storm. Heat thunderstorms, as well as cyclonic, depend principally

upon a convectional overturning of the atmosphere. The unstable condition may result from local heating in moist, quiet air, not under the domination of either cyclonic or anticyclonic systems. Thunderstorms occurring under such conditions fall under the first head. Their sphere of action is generally limited and they die away at nightfall, reappearing the next day and for many days in succession in particularly favorable regions. The Florida Peninsula is advantageously conditioned with respect to the development of heat thunderstorms. So, also, are the many parks and valleys of Colorado and adjoining States in the Rocky Mountain region, where heat thunderstorms are of daily occurrence in the summer season.

Cyclonic thunderstorms, as the name indicates, occur in connection with cyclonic disturbances, which generally move in an easterly direction over the northern third of the United States east of the Rocky Mountains. These storms are not necessarily confined to the southeastern quadrant of the cyclone, as has been frequently stated. In the northeastern Rocky Mountain slope and the Upper Missouri Valley they occur most frequently in the northwest quadrant of the storm on the dividing line between the cool westerly and warm southerly winds. East of the Alleghenies they occur more frequently at the moment the center of the disturbance passes. They also occur along the Middle Atlantic coast when the center of the disturbance has reached the mouth of the St. Lawrence. Plate III shows the weather conditions under which thunderstorms developed in the rear of a cyclone over a narrow belt extending from Arkansas to New England. Some of the most violent thunderstorms occur when the pressure gradients are weak and the cyclonic circulation of the winds uncertain and ill defined. In fact, a well-defined storm with moderate gradients and fresh winds is detrimental to thunderstorm formation.

Returning now to the statement on a previous page respecting the violence of thunderstorms in different parts of the country, we would remark that the thunderstorms of the Gulf and South Atlantic States are largely due to more or less local convectional overturning. It is probable that less energy is expended in their formation than in the case of cyclonic thunderstorms of the more northern districts which lie directly in the path of cyclonic storms. In the last-named districts thunderstorm activity is more general and widespread. It continues into and sometimes through the night hours with unabated severity. The energy involved, both molecular and mechanical in the movement of a general disturbance, is clearly much greater than that of the local thunderstorms of the Gulf and South Atlantic States. The squall winds of northern thunderstorms are in most cases more severe than those of the South; but, unfortunately for our argument, the force of the wind is not always a measure of the electrical energy of the storm. It is true that destructive lightning strokes sometimes fall from storm-clouds that are not especially ominous or threatening; moreover,

intense outbursts of electrical energy in connection with thunderstorms sometimes break out almost simultaneously over considerable areas without any decided antecedent storm movement. These violent outbursts seldom occur except along the path most frequented by cyclonic thunderstorms. This single fact, whatever be the cause, will largely account for the greater loss of life and property in the North and West as compared with the South.

Some situations are more dangerous than others during the prevalence of a thunderstorm. In what follows the reader is advised of the exposures that should be avoided.

Much of this matter is a reprint from Bulletin No. 26, *Lightning and the Electricity of the Air*.

It is not judicious to stand under or near trees during thunderstorms, in the doorway of barns, close to cattle, near chimneys and fire places, or near the terminus of a wire clothesline. Avoid suspending the latter between a corner of the house and a convenient tree, rather let it be hung from one tree or post to another. On the other hand, there is not much sense in going to bed or trying to insulate oneself in feather beds. Small articles of steel, also, do not have the power to attract lightning, as it is popularly put, or determine the path of discharge.

Just in advance of thunderstorms, whether because of the varying electrical potential of the air, or of the changing conditions of temperature, humidity, and pressure, and failure of the nervous organization to respond quickly, or to whatever cause it may be due, it can not be denied that there is in certain individuals much suffering from depression at these times. It is, perhaps, possible that these sufferings may be alleviated. Apart from this many people suffer greatly from alarm during the prevalence of thunderstorms, somewhat unnecessarily, it is thought. Grant even that the lightning is going to strike close in one's vicinity. There are many flashes that are of less intensity than we imagine, discharges that the human body could withstand without permanent serious effects. Voltaire's caustic witticism "that there are some great lords which it does not do to approach too closely, and lightning is one of these," needs a little revision in these days of high potential oscillatory currents. Indeed, the other saying, "Heaven has more thunders to alarm than thunderbolts to punish," has just so much more point to it, as it is nearer the truth. One who lives to see the lightning flash need not concern himself much about the possibility of personal injury from that flash.

Finally, if one should be in the vicinity of a person who has just been struck by lightning, no matter if the person struck appears to be dead, go to work at once and try to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration

and circulation. Do not cease in the effort to restore animation in less than one hour's time. For an excellent illustration of a case of severe lightning shock and recovery, due, it would seem, to prompt action by the medical gentlemen present, all who are interested may consult the Medical News, August 11, 1888. A number of cases corroborative of this view are on record in various medical journals.

No matter which method for respiration is used, it is important to maintain the warmth of the body by the application of hot flannels, bottles of hot water, hot bricks, warm clothing taken from bystanders, etc.

Firmly and energetically rub the limbs upward so as to force the blood to the heart and brain. If an assistant is present, let him attend to this. Remember above all things that nothing must interrupt your efforts to restore breathing.

When swallowing is established a teaspoonful of warm water, wine, diluted whisky or brandy, or warm coffee should be given. Sleep should be encouraged. In brief—

1. Make the subject breathe by artificially imitating the respiratory movements of the chest.
2. Keep body warm.
3. Send for a physician.

Of the visible effects of lightning stroke upon the human body little more can be said than that sometimes burns, usually superficial, have been noticed, frequently red lines or markings, which are localized congestions of the small blood vessels of the skin. These, from their irregularities and branchings, have led to the fanciful idea of photographs of trees, etc.

In conclusion, it may be said that lightning frequently causes a temporary paralysis of the respiration and heart beat, which if left alone will deepen into death, but intelligently treated will generally result in recovery.

TABLE I.—*Killed by lightning, 1900.*

State or Territory.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.
Alabama.....		2	4	9	4	6	.....	1	.....	26
Arkansas.....		1	4	1	3	3	3	.....	.....	12
Colorado.....	1	1	5	2	7	1	.....	.....	.....	17
Connecticut.....			4	3	.....	1	.....	.....	.....	8
Delaware.....				1	1	.....	.....	.....	.....	2
District of Columbia.....				1	.....	.....	.....	.....	.....	1
Florida.....	1	1		4	.....	7	2	.....	.....	8
Georgia.....		1	1	3	7	7	.....	.....	.....	19
Illinois.....			12	4	9	13	4	.....	.....	42
Indiana.....			7	6	5	2	1	.....	.....	21
Indian Territory.....				1	1	1	1	.....	.....	3
Iowa.....	1	3	11	15	5	1	1	1	.....	37
Kansas.....	2		2	8	2	2	2	1	.....	17
Kentucky.....		4	6	2	8	.....	.....	.....	.....	20
Louisiana.....	1	1	4	1	3	.....	.....	.....	.....	10
Maine.....		1	3	3	.....	.....	.....	.....	.....	7
Maryland.....		2	3	8	1	.....	.....	.....	.....	14
Massachusetts.....			1	4	.....	.....	.....	.....	.....	5
Michigan.....		11	4	5	7	.....	.....	.....	.....	27
Minnesota.....		2	5	4	6	3	1	.....	.....	21
Mississippi.....		1	2	6	1	.....	.....	.....	.....	10
Missouri.....	1	3	7	5	3	1	2	.....	.....	22

TABLE I.—*Killed by lightning, 1900—Continued.*

State or Territory.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.
Montana.....				2						2
Nebraska.....			9	8	3	4	1	4		29
New Hampshire.....				2						2
New Jersey.....			1	1	3	11				16
New Mexico.....				1	1	1	1			4
New York.....			1	9	13	14		1		38
North Carolina.....		2	2	4	8	8	1			25
North Dakota.....		1		4	2	2				9
Ohio.....			1	11	8	3				23
Oklahoma.....			1	1	2				1	5
Pennsylvania.....			7	5	27	19	1			59
Rhode Island.....				2		1				3
South Carolina.....	1	2		4	4					18
South Dakota.....	2	2		6	4		2	3		19
Tennessee.....	1	5			4	4	1			15
Texas.....	1	3	9	2	7	5	1			28
Utah.....						1				1
Vermont.....					2				1	3
Virginia.....		1	2	6	11	1	5			26
Washington.....							1			1
West Virginia.....			2	4		2				8
Wisconsin.....				5	10	8		4		27
Wyoming.....					2	1				3
Total.....	2	24	102	168	202	166	31	17	1	713
Cuba.....						2				
Porto Rico.....						1				

TABLE II.—*Injured by lightning, 1900.*

State or Territory.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.	
Alabama.....			1	3	3	6	1	2		19	
Arkansas.....				3	1	1	2			7	
California.....				3						3	
Colorado.....				5		1				6	
Connecticut.....			1	3		3	1			8	
Delaware.....		1			8	4				13	
District of Columbia.....				2						2	
Florida.....				3	1	4	2			10	
Georgia.....		2		3	4	8				17	
Illinois.....	1	26		7	4	17	1	1		57	
Indiana.....		5		24	15	6	4	1		55	
Indian Territory.....						1				1	
Iowa.....		3		9	21	6				39	
Kansas.....	3			2			1			6	
Kentucky.....		9		4	5	3				21	
Louisiana.....				1		2	2			5	
Maine.....					6					6	
Maryland.....	1	2		7	8	8				26	
Massachusetts.....		1		7	8	1			2	22	
Michigan.....		12		19	11	14	1			57	
Minnesota.....				2	3	11	2	2		20	
Mississippi.....				2						2	
Missouri.....	1	1		7	10	4	2	4		29	
Montana.....				2						2	
Nebraska.....		5		4	2	3	2	1		17	
New Hampshire.....				4	2					6	
New Jersey.....				3	11	20	29	1		64	
New Mexico.....						1	1			2	
New York.....	1	11		19	38	26	3	2		100	
North Carolina.....			1	5	5	3				14	
North Dakota.....			1			4				5	
Ohio.....		2		16	33	22	3	1		77	
Oklahoma.....		1					1	6		8	
Pennsylvania.....		13		30	46	29	6	1		125	
Rhode Island.....					5	4				9	
South Carolina.....			1		1	10				12	
South Dakota.....			1			2				3	
Tennessee.....		2		4	1	3				10	
Texas.....	1	2		4	3	9	8			27	
Vermont.....					1	1				2	
Virginia.....			1	2	5	4	4			16	
West Virginia.....			4	3						7	
Wisconsin.....			1	2	6	10	10	3	4	36	
Total.....		1	13	117	221	270	244	79	26	2	973

TABLE III.—Deaths by lightning, 1890–1900.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	
1890			2	6	8	37	55	12	9	6	1	2	120	
1891				13	23	73	52	34	9	6	1	2	204	
1892				5	27	74	67	54	15	6	1	2	251	
1893				5	19	17	66	73	18	8	2	1	209	
1894			2	6	14	45	96	60	78	29	6		336	
1895				5	29	66	109	123	78	16			426	
1896				1	6	26	71	45	89	75	21	6	341	
1897				1	11	8	44	107	109	61	14	3	362	
1898					1	2	44	71	110	86	41	12	367	
1899			3	1	10	11	108	128	120	133	43	2	563	
1900					2	24	102	168	202	166	31	17	1	713
Sums	3	5	48	157	555	974	1,060	795	227	54	11	3	3,772	
Average													377	

^a Not used in computing the annual average.

TABLE IV.—Number of deaths by lightning in the United States during the five years, 1896, 1897, 1898, 1899, and 1900; also the ratio of deaths in a million living, by rural population and total population and per unit area of 10,000 square miles.

State and district.	Total population (1900).	Total number of fatal cases in 5 years, 1896–1900.	Rate per million.		Average number of deaths annually per unit area of 10,000 sq. m.
			Rural population.	Total population.	
New England:					
Maine	694,466	14	5	4	
New Hampshire	411,588	6	5	3	
Vermont	343,641	12	8	7	
Massachusetts	2,805,346	27	8	2	
Rhode Island	428,556	4	10	2	
Connecticut	908,420	16	8	4	
Average		13.2	7	4	2.3
Middle Atlantic States:					
New York	7,268,894	124	11	3	
New Jersey	1,883,669	37	10	4	
Pennsylvania	6,302,115	186	11	6	
Delaware	184,735	7	13	8	
Maryland	1,188,044	37	12	6	
Virginia	1,854,184	72	9	8	
Average		77.2	11	6	6.0
South Atlantic States:					
North Carolina	1,893,810	58	6	6	
South Carolina	1,340,316	76	12	11	
Georgia	2,216,331	62	6	6	
Florida	528,542	29	13	11	
Average		56.2	9	8	2.2
Gulf States:					
Alabama	1,828,697	68	8	7	
Mississippi	1,551,270	27	4	3	
Louisiana	1,381,625	31	6	4	
Texas	3,048,710	109	8	7	
Average		58.8	6	5	1.1
Central Mississippi Valley:					
Arkansas	1,311,564	49	8	7	
Oklahoma and Indian Territory	790,391	29	8	7	
Missouri	3,106,665	81	8	5	
Iowa	2,231,853	95	10	9	
Illinois	4,821,550	124	10	5	
Average		75.6	9	7	2.6

TABLE IV.—*Number of deaths by lightning in the United States during the five years, 1896, 1897, 1898, 1899, and 1900, etc.—Continued.*

State and district.	Total population (1900).	Total number of fatal cases in 5 years, 1890-1900.	Rate per million.		Average number of deaths annually per unit area of 10,000 sq. m.
			Rural population.	Total population.	
Upper Mississippi Valley:					
Minnesota.....	1,751,394	69	11	8	
Wisconsin.....	2,069,042	72	10	7	
Michigan.....	2,420,982	89	11	7	
Average .....	.....	76.7	11	7	2.4
Upper Missouri Valley and Plains:					
North Dakota.....	319,146	32	21	20	
South Dakota.....	401,570	40	20	20	
Nebraska.....	1,066,300	70	16	13	
Kansas.....	1,470,495	52	8	7	
Average .....	.....	48.5	16	15	1.3
Ohio Valley and Tennessee:					
Indiana.....	2,516,462	124	10	10	
Ohio.....	4,157,545	135	11	6	
Kentucky.....	2,147,174	71	8	7	
Tennessee.....	2,020,616	70	8	7	
West Virginia.....	958,800	28	6	6	
Average .....	.....	85.6	9	7	4.7
Rocky Mountain and Plateau Region:					
Montana.....	243,329	22	25	18	
Wyoming.....	92,531	11	31	24	
Colorado.....	539,700	48	29	18	
New Mexico.....	195,310	8	8	8	
Arizona.....	122,931	8	13	13	
Utah.....	276,749	3	3	2	
Nevada.....	42,335	0	0	0	
Idaho.....	161,772	1	1	1	
Average .....	.....	12.6	14	10	0.2
Pacific coast:					
California.....	1,485,053	2	0	0	
Oregon.....	413,536	1	1	0	
Washington.....	518,103	1	1	0	
Average .....	.....	1.3	1	0	0.0

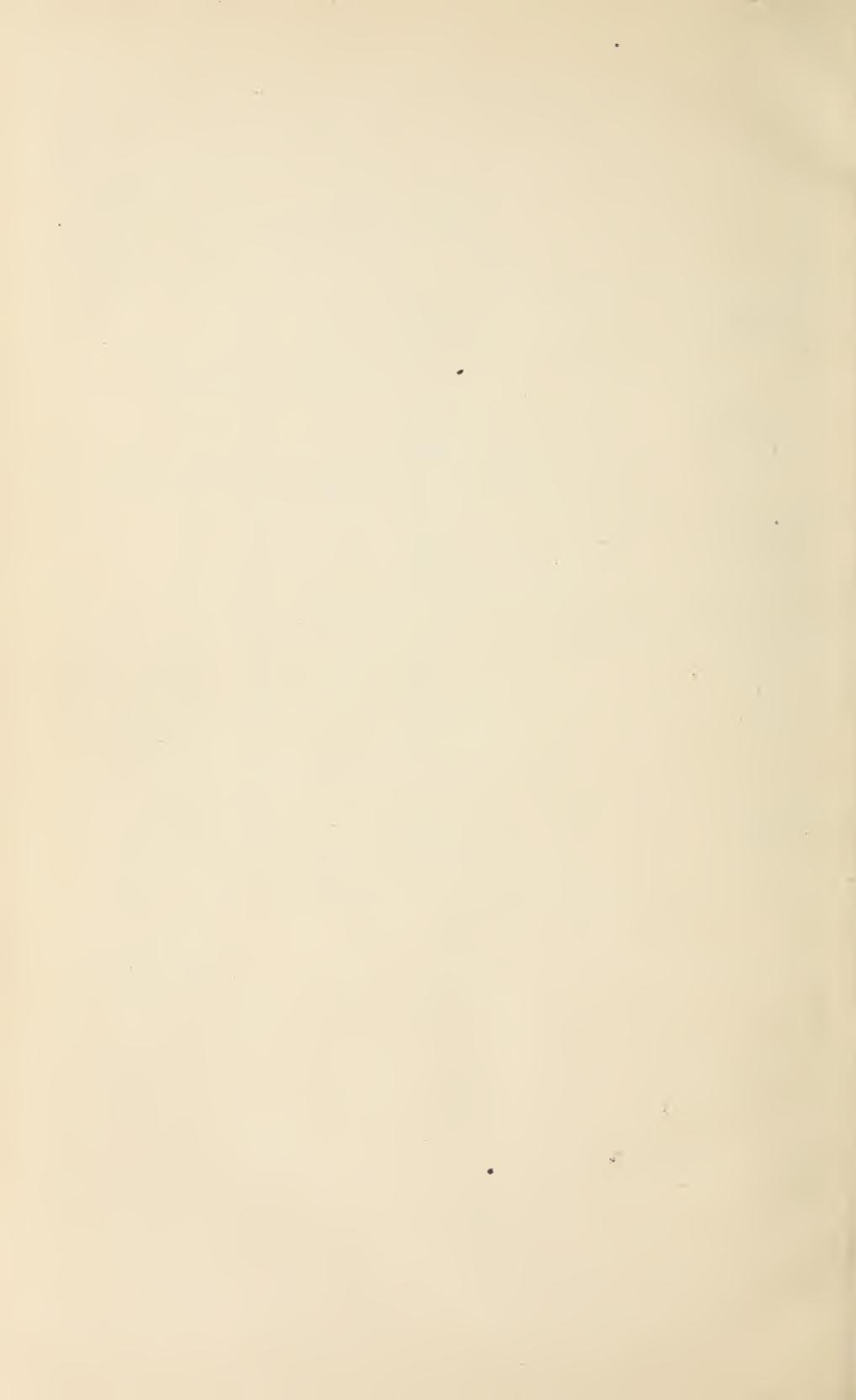


Plate I.

AVERAGE ANNUAL NUMBER OF THUNDERSTORM DAYS IN THE UNITED STATES

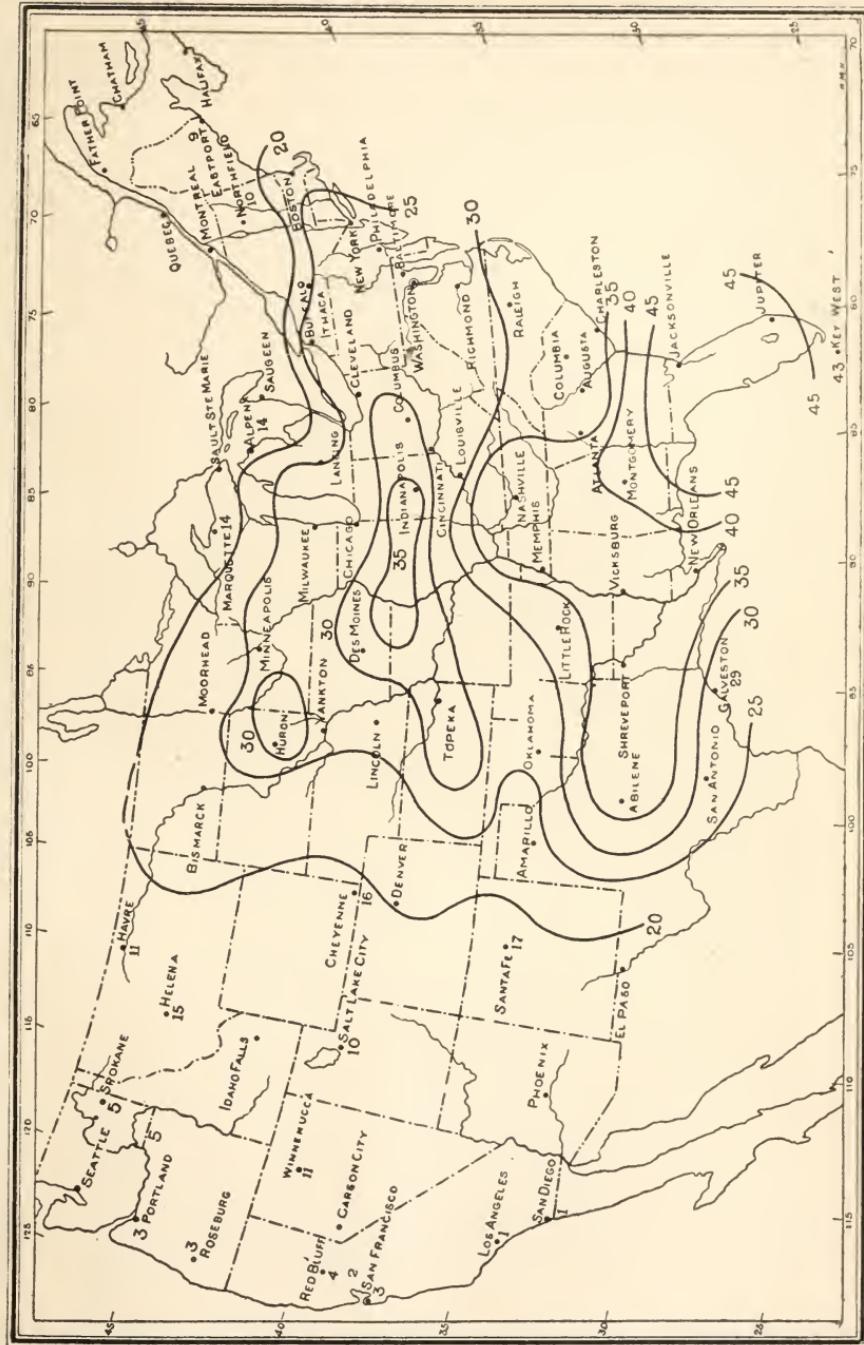
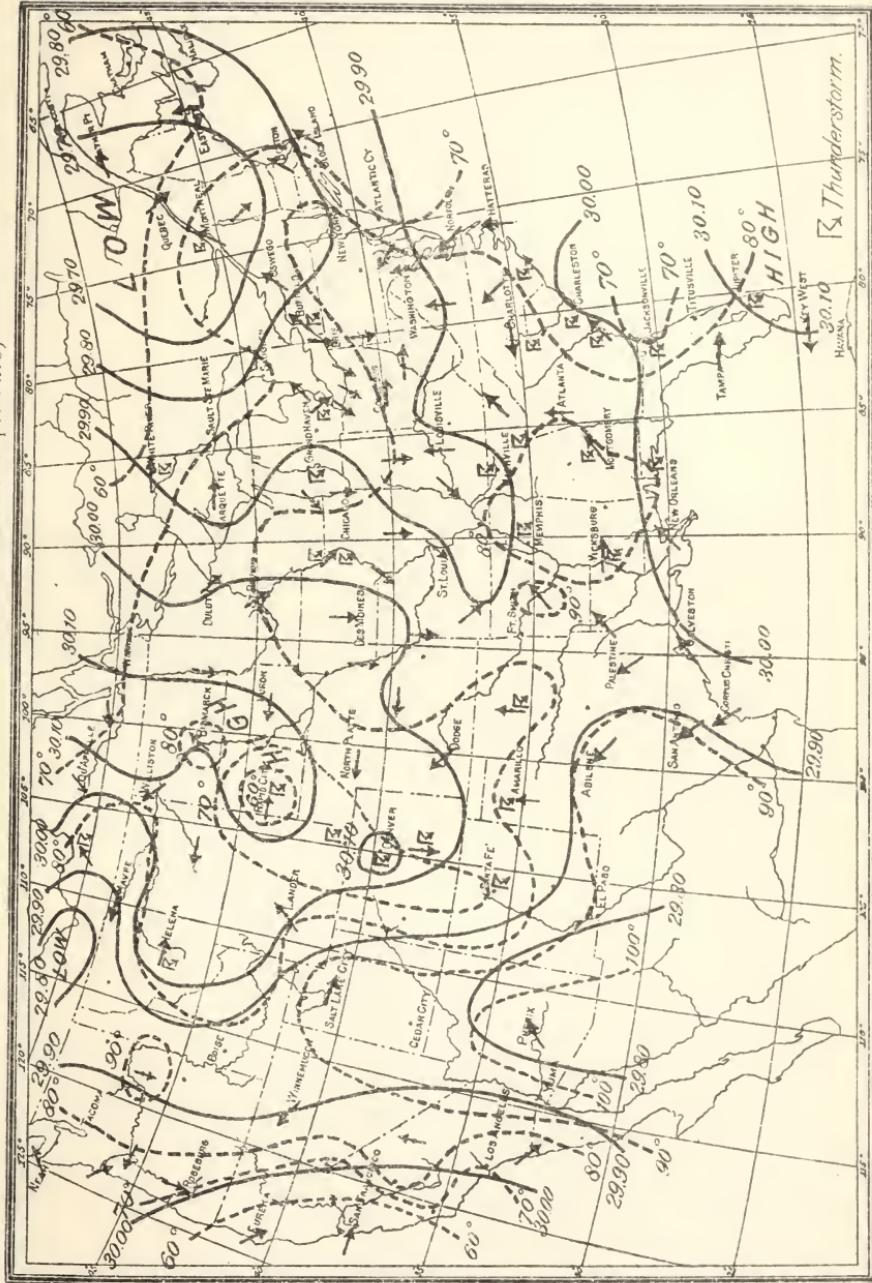


PLATE III.
Daily weather map July 8th, 1898, 8 p. m.

(Thunderstorms southwest of an area of low pressure)





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